PHASE-FIELD SIMULATIONS OF THE MICROSTRUCTURAL DEVELOPMENT DURING DIRECTIONAL SOLIDIFICATION IN A CHANNEL

T. Takaki[a] , **T. Fukuoka**[a] **, and Y. Tomita**[b]

[a]Department of Ocean Electro-Mechanical Engineering
Kobe University of Mercantile Marine
5-1-1 Fukaeminami, Higashinada, Kobe, 658-0022, Japan
takaki@cc.kshosen.ac.jp
fukuoka@cc.kshosen.ac.jp

[b]Graduate School of Science and Technology
Kobe University
1-1 Rokkodai, Nada, Kobe, 657-8501, Japan
tomita@mech.kobe-u.ac.jp

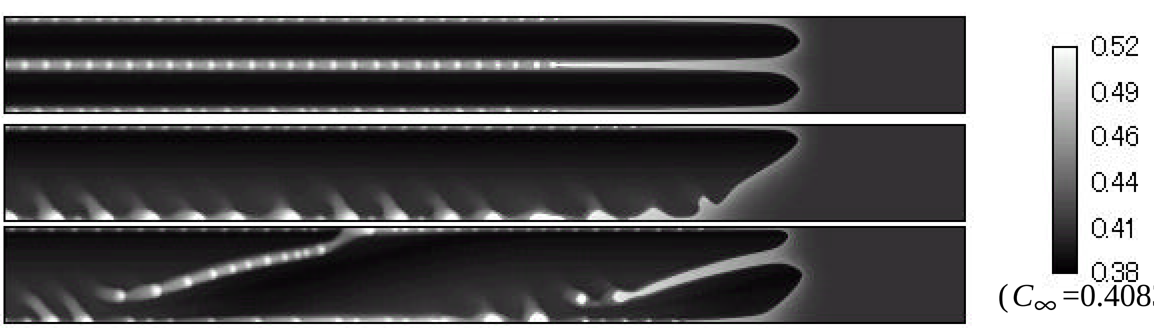
It is well known that a significant morphological changes occur when cells or dendrites grow inside a narrow channel, such as an interstice between fibers of metal matrix composites. Furthermore, it has been reported that a complete cellular or dendritic structure is not found to be stable inside the channel whose direction does not coincide with one of the preferred dendritic growth orientation. In this study, phase-field simulations of a binary alloy, Ni-Cu, are carried out to examine the microstructural development during directional solidification in a channel.

The phase-field equations, materials parameters, and mesh size used here are identical with those used in reference [2], except that finite element approach is applied as a numerical method. Figure 1 shows the numerical results of concentration field at the quasi-steady state after initial interface breakdown. Here, a temperature gradient G is 2.15K/μm, a frame moving speed V is 0.0025m/s, and, a computational domain is 44×4.4μm (1000×100 mesh). The effects of a difference between the direction of the temperature gradient and dendritic growth orientation are also clarified in Fig.1. The dendritic growth direction is changed by angle, θ_0, which is measured counterclockwise from the *x axis*, in equation for anisotropy, $\varepsilon(\theta)= \varepsilon\{1+\gamma\cos(k(\theta-\theta_0))\}$. Two cells, a half-dendrite, and new dendrite growing from near the under wall are observed in Fig.1 (a), (b), and (c), respectively. In Fig.1(c), since the new dendrite periodically grows, the microstructure never attains a quasi steady structure. The similar microstructural developments are observed in some experimental results [(1)]. When the computational domain becomes 44×2.2μm, a half-cell is observed for both θ_0 =5 and 15 degree in a steady-state manner.

(a) θ_0 =0 degree

(b) θ_0 =5 degree

(c) θ_0 =15 degree



(C_∞ =0.40831)

Fig.1 Concentration field at the quasi-steady state (t = 35200μs)

References

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[2] W. J. Boettinger, and J. A. Warren, “Simulation of the cell to plane front transition during directional solidification at high velocity,” *Journal of Crystal Growth*, 200, p. 583-591, 1999.